

1 AXLE ASSEMBLY
2 (123871.1)

3

4 FIELD OF THE INVENTION

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6 This invention relates to improvements in axle assemblies, and more
7 particularly to improvements in motor vehicle axle assemblies.

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9 BACKGROUND OF THE INVENTION

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11 Axles are used as main supports for tire assemblies and other components in
12 motor vehicles. The tires are mounted at each end of the axle, and other items such
13 as shock absorbers, jounce bumpers, differential carriers, stay bars, yokes, and
14 control arms, etc. are attached to the axle, often by welding several components
15 together. Common automotive axle assemblies are referred to as Salisbury designs.16 With this type of axle assembly, an axle tube is formed of steel and pressed into
17 each one of a pair of differential carrier trunnions made of ductile iron, with each
18 tube being plug welded to the carrier through radially extending holes formed in the
19 corresponding carrier trunnion. Thus, known automotive axle assemblies are fairly
20 complex, with numerous mounting and structural components fastened and welded
21 together. Such complexity increases costs, adds to manufacturing time, and has the
22 potential to introduce some tolerance and alignment concerns.

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1 It has been suggested that forming the axle assembly of ductile iron through a
2 lost foam process may alleviate some of these concerns. However, practical
3 engineering constraints have kept such designs from being commercialized,
4 including, for example, the fact that ductile iron is difficult to weld (to the differential
5 carrier, for example). Further, lost foam processes have not been used as it was
6 thought that components as large and complex as axle assemblies could not be
7 made efficiently due to high temperatures of some materials, the increased difficulty
8 in controlling vent pressure during the mold process, etc. It would be highly
9 desirable to provide an axle tube assembly which is less expensive, easier to
10 assemble and lighter than known axle tube assemblies which incorporates as many
11 parts as possible into a single axle assembly.

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13 SUMMARY OF THE INVENTION

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15 In accordance with a first aspect, an axle assembly serves as a primary
16 structural member for a motor vehicle and comprises an axle tube having a first end
17 and a second end and a mounting module formed as a unitary extension of the axle
18 tube. At least one steel insert is positioned near the first end, and the steel insert is
19 adapted to be welded to a differential carrier to secure the axle tube to the
20 differential carrier. The axle assembly may also have an axle tube formed unitary
21 with the differential carrier.

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1 From the foregoing disclosure and the following more detailed description of
2 various preferred embodiments it will be apparent to those skilled in the art that the
3 present invention provides a significant advance in the technology of axle
4 assemblies. Particularly significant in this regard is the potential the invention
5 affords for providing a high quality, low cost incorporating numerous elements into
6 one molded part. Additional features and advantages of various preferred
7 embodiments will be better understood in view of the detailed description provided
8 below.

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10 **BRIEF DESCRIPTION OF THE DRAWINGS**

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12 Fig. 1 is a perspective view of an axle assembly in accordance with a
13 preferred embodiment, showing left and right axle assemblies connected to a
14 differential.

15 Fig. 2 is a perspective view of the left axle assembly of Fig. 1

16 Fig. 3 is a perspective view of the right axle assembly of Fig. 1

17 Fig. 4 is a perspective view of an alternate preferred embodiment of an axle
18 assembly where the differential carrier is formed unitary with an axle tube.

19 Fig. 5 is another perspective view of the axle of assembly of Fig. 4.

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21 It should be understood that the appended drawings are not necessarily to
22 scale, presenting a somewhat simplified representation of various preferred features
23 illustrative of the basic principles of the invention. The specific design features of

1 the axle assembly as disclosed here, including, for example, the specific dimensions
2 of the steel insert, will be determined in part by the particular intended application
3 and use environment. Certain features of the illustrated embodiments have been
4 enlarged or distorted relative to others to facilitate visualization and clear
5 understanding. In particular, thin features may be thickened, for example, for clarity
6 of illustration. All references to direction and position, unless otherwise indicated,
7 refer to the orientation illustrated in the drawings.

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9 DETAILED DESCRIPTION OF CERTAIN PREFERRED EMBODIMENTS

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11 It will be apparent to those skilled in the art, that is, to those who have
12 knowledge or experience in this area of technology, that many uses and design
13 variations are possible for the axle assembly disclosed here. The following detailed
14 discussion of various alternative and preferred features and embodiments will
15 illustrate the general principles of the invention with reference to an axle assembly
16 suitable for use in automotive applications. Other embodiments suitable for other
17 applications will be apparent to those skilled in the art given the benefit of this
18 disclosure.

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20 Referring now to the drawings, in Fig. 1 shows an axle 10 in accordance with
21 a preferred embodiment comprising left and right axle assemblies 120, 110 having
22 corresponding axle tubes 14, 15 which are connected to a differential carrier 90.
23 The differential carrier may be formed of ductile iron, aluminum or steel, for example.

1 Fig. 2 shows the right side axle assembly 110 and Fig. 3 shows the left axle
2 assembly 120. In this preferred embodiment, each of the axle assemblies may be
3 connected to the differential carrier at a corresponding first end 75, 73 of each axle
4 tube 15, 14, respectively. A kingpin yoke 12 is shown formed as a unitary extension
5 of the axle tubes at corresponding second ends 76, 74. In accordance with a highly
6 advantageous feature, the axle tubes are formed unitary with any one or more of
7 numerous mounting brackets, forming a low cost structural mounting module to
8 which many different motor vehicle components can be attached. Reference herein
9 to the axle assembly in preferred embodiments as one-piece or unitary is intended to
10 mean that the axle assembly is formed of a single, seamless body of material.
11 Similarly, reference to features or elements, such as the kingpin yoke, shock
12 absorber attachment bracket, etc., as being "unitary" defines them as part of the
13 single seamless body of material forming the axle assembly, generally as
14 protrusions, recesses and like formations.

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16 Unitary mounting modules which can be incorporated as a single piece with
17 the axle tubes are numerous and can comprise, for example, a yoke, such as a
18 kingpin yoke 12, a shock absorber attachment bracket 16, a stay bar attachment
19 bracket 28, an upper control arm attachment bracket 22 (shown in the embodiment
20 in Fig. 4 as a unitary extension from the differential carrier 190), a lower control arm
21 attachment bracket 24, a spring seat 20 which could be for a coil spring, a leaf
22 spring, or an air spring, for example, a jounce bumper bracket 30, a steering damper
23 attachment bracket 26 (seen in Fig. 2), and a track bar attachment bracket 18. Of

1 course, such bracketry need not be formed unitary with the axle tube in combination
2 with all of the other brackets, and some bracketry may not exist on some models of
3 axle. Other elements suitable for incorporation into the mounting module will be
4 readily apparent to those skilled in the art given the benefit of this disclosure and can
5 comprise a steering stabilizer bracket, McPherson strut attachment bracket, a
6 torsion bar attachment bracket, a coil spring over shock absorber bracket, a pinion
7 nose bracket, a lateral link or longitudinal link/control arm attachment bracket, a
8 panhard rod bracket, a trailing link attachment bracket, a damper bracket, a parking
9 brake bracket, a height sensor attachment bracket, or a load sensing brake pressure
10 attachment bracket.

11

12 The unitary axle assembly may be cast using a lost foam process. In the lost
13 foam process, a foam pattern having the geometry of the desired part is created,
14 coated with a refractory and then placed in a container or flask and surrounded by
15 sand. Molten metal is then poured into the foam, which melts and vaporizes the
16 foam, leaving a replica of the foam. This can then be machined as required to
17 produce the final part. Access holes 93 may be provided in the components to
18 assist in the casting process. The lost foam process is highly advantageous in many
19 ways. For example combining multiple parts into one can reduce overall mass,
20 enhance vibration damping characteristics, allow for better dimensional consistency,
21 eliminates assembly processes such as welding, and enhance stiffness. Further,
22 various components may be inserted into the mold so as to form an integral
23 assembly. For example, in some preferred embodiments the axle tubes 14, 15 and

1 unitary mounting modules may be formed of, for example, ductile iron. It is difficult
2 to weld ductile iron parts together, as is the case where the differential carrier is
3 formed of ductile iron as well.

4

5 In accordance with a highly advantageous feature designed to overcome this
6 problem, the first ends of each axle tube 14, 15 are provided with at least one steel
7 insert 91, positioned between the corresponding end and spacer 92, and the
8 differential carrier 90 is provided with corresponding openings 88. In the preferred
9 embodiment shown in the drawings, three steel inserts are provided. When the
10 differential carrier and the axle tubes are assembled together the steel inserts 91
11 align with the openings 88, where the steel inserts can be welded to the ductile iron
12 differential carrier. Preferably the steel inserts are insert molded into to the axle
13 assembly.

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15 Figs. 4 and 5 show an alternate preferred embodiment with even fewer
16 separate components than the above described embodiments. Left 140 and right
17 130 axle assemblies are provided, and here axle assembly 130 and the differential
18 carrier 190 are formed as a unitary, one-piece construction, again preferably by
19 making use of the lost foam process. In this preferred embodiment, the axle tube,
20 mounting module and differential carrier can all be formed of ductile iron, for
21 example. The other axle assembly 140, may be attached to the differential carrier
22 by one of various suitable methods, including using steel inserts 91 and alignment
23 holes 88 in the differential carrier 190.

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2 From the foregoing disclosure and detailed description of certain preferred
3 embodiments, it will be apparent that various modifications, additions and other
4 alternative embodiments are possible without departing from the true scope and
5 spirit of the invention. The embodiments discussed were chosen and described to
6 provide the best illustration of the principles of the invention and its practical
7 application to thereby enable one of ordinary skill in the art to utilize the invention in
8 various embodiments and with various modifications as are suited to the particular
9 use contemplated. All such modifications and variations are within the scope of the
10 invention as determined by the appended claims when interpreted in accordance
11 with the breadth to which they are fairly, legally, and equitably entitled.